LESSON 6

STWAVE Analysis

6.1 Introduction

This lesson gives a description of the *STWAVE* model and interface along with an example of its use. Data from Shinnecock Bay, New York has been set up as an example. In this example, you will use the mesh from the previous lesson for *ADCIRC*. An *STWAVE* grid will be created over a small section of the *ADCIRC* mesh.

6.2 Reading in the ADCIRC files

First, open the mesh of Shinnecock Bay used for *ADCIRC*. (This is the "Shinnecock.grd" file used in *Lesson 5*.) Next, open the fort.64 file.

The grid file is defined in geographic coordinates, so specify the current coordinate system to be Geographic NAD 83 (*Edit* | *Current Coordinates…*). Also make sure the vertical units are meters.This lets *SMS* know what coordinate system the data is referenced to and allows conversion to other systems. *STWAVE* is built to use metric Cartesian coordinates, so convert the *ADCIRC* data to state plane. The zone that includes Shinnecock Bay is New York, Long Island (*Edit* | *Coordinate Conversions…*).

6.3 Converting ADCIRC

The *ADCIRC* data includes a finite element mesh. We will extract bathymetric and coastline data from this mesh to aid in the creation of an *STWAVE* simulation. (We could also start with the same scattered data and coastline that was used for *ADCIRC*.) First, we will convert the nodal data to a scatter set which will allow interpolation of depths to the *STWAVE* grid. Second, we will convert mesh boundaries to feature arcs that will aid in the definition of land area in the *STWAVE* grid.

6.3.1 Converting to Scatter

The mesh file was read into the *Mesh* module . Converting the data into scattered data points (which are accessed in the *Scatter* module) will make it possible to interpolate to a Cartesian grid. To convert the data to scatter points.

1. Still in the *Mesh* module , go to *Data | Mesh -> Scatterpoint*, enter a name for the scatter set (the default "*scatter*", would work or enter your own) and push *OK*.

6.3.2 Converting to Map Arcs

The *ADCIRC* mesh defines the coastlines, which are useful in setting up the *STWAVE* grid. The coastlines need to be in the form of arcs in the *Map Module*. To create these arcs:

1. In the *Mesh* module and choose *Data | Mesh -> Map*.

2. Select the *Nodestrings -> Arcs* option.

3. Select the *Create New Coverage* option.

4. Enter a name for the coverage (the default "*New Coverage*" would work or enter your own), and choose "*Stwave"* as the type.

5. Push *OK*.

Now that we have the data represented as a scatter set and feature arcs, we no longer need the ADCIRC data in memory. For efficiency, turn off the display of all mesh data in the *Display Options Dialog*.

6.4 STWAVE Conceptual Model

The *STWAVE* simulation is built on a Cartesian grid of square cells. The grid can be constructed directly is the *Cartesian Grid Module*, but constructing the grid from a conceptual model is recommended because it allows you to interactively place the grid over site map data. The conceptual model for a Cartesian grid is based on a *grid frame*. The grid frame is created in the *Map* module .

6.4.1 Creating the Cartesian Grid Frame

To create the grid frame:

1. Switch to the *Map* module .

2. Go to *Feature Objects* | *Grid Frame* and push the *New Grid* button.

3. A grid frame appears around the entire data set. (You may need to click on the *Frame macro* in the *Grid Frame* dialog.) The grid frame includes eight handles (dots on the sides and corners) and an extra handle extending from the *i* or local *x* axis of the frame. The handles on the frame can be drug with the mouse to resize the grid frame. The extra handle is used to orient the frame. This *STWAVE* analysis will only include the area around the inlet to Shinnecock Bay. So use the handles on the corners and sides of the grid frame to decrease the frames size and position the frame roughly over the inlet of the bay (as shown if Figure 6-1).

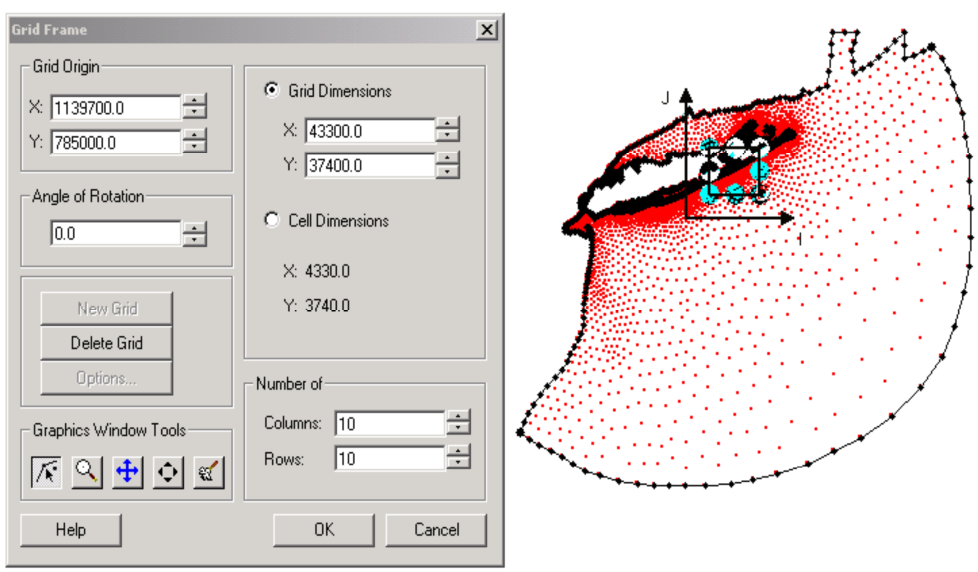


Figure 6-1 Grid frame dialog and gridframe positioned around Shinnecock Bay.

4. Once the grid frame is roughly in position, use the Zoom Tool on the Grid Frame dialog to zoom into the area around the bay (and gridframe). You may need to make the grid frame even smaller and zoom in again until you see what is shown in (Figure 6-2)

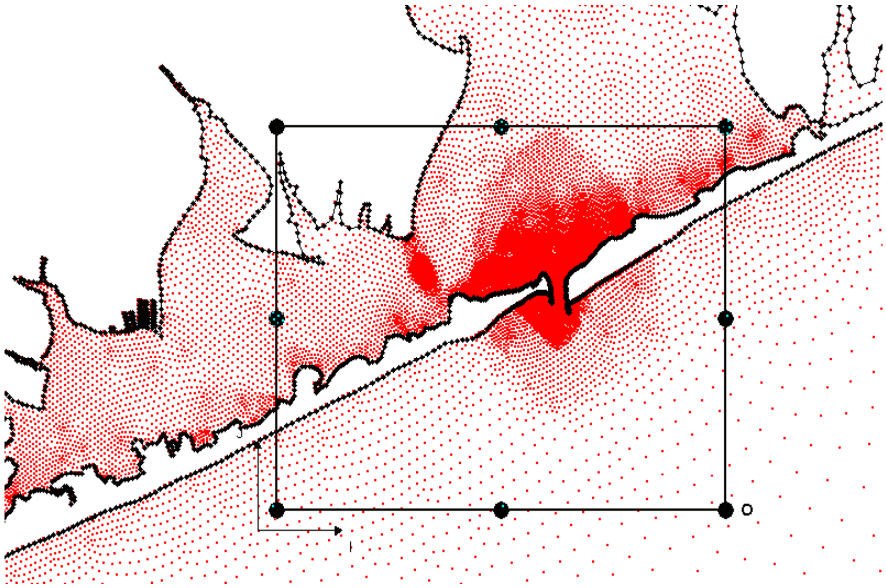


Figure 6-2 Close up of grid frame

5. In *STWAVE*, the waves must propagate in the *i* direction. That means that for the orientation shown in Figure 6-2 waves would be going east. We want to consider wave propagation into the inlet, so rotate the frame counterclockwise until the rotation handle is on the landward side of the frame. Then resize and position the grid frame as shown in Figure 6-3. Once you have the grid frame positioned, enter the following values in the *Grid Frame* dialog to assure consistency in the remainder of the lesson.

Parameter	Value
Grid Origin X	433910.0
Grid Origin Y	72860.0
Grid Dimension X	5700
Grid Dimension Y	11000
Angle of Rotation	111

Note: Remember that an *STWAVE* grid must always be oriented with the origin in the water and the local X or I axis pointing towards the coast.

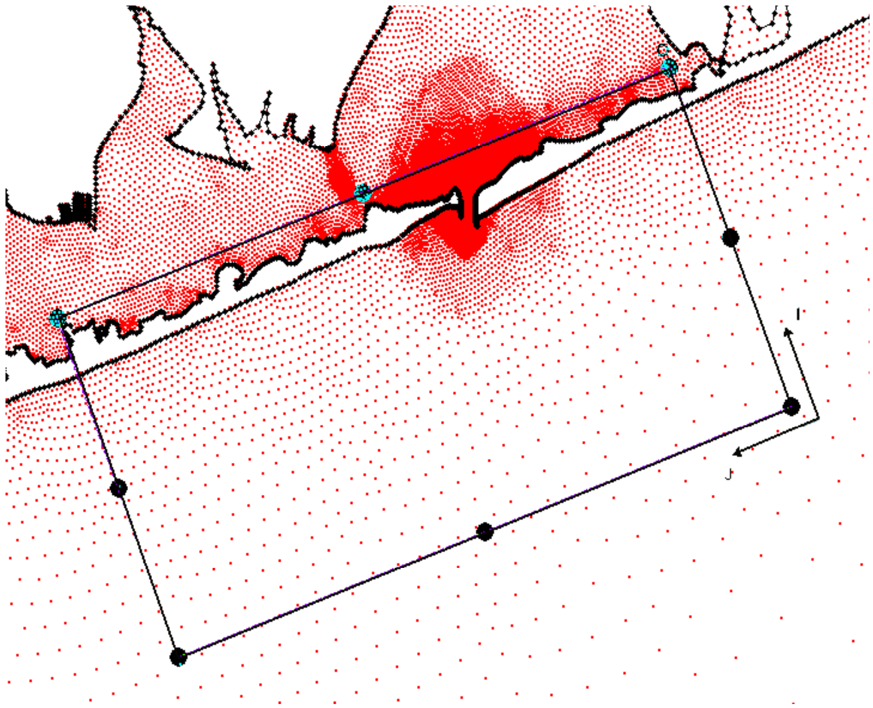


Figure 6-3 Rotated Grid Frame

6. Push *OK* when you are done positioning the frame.

6.4.2 Creating Coastline Arcs

Before filling the interior of the grid frame with cells, we need to specify which cells will be viewed as ocean cells by the model. All cells that have negative depths are interpreted as land. Therefore, one way to assign ocean and land cells is to use bathymetric data. However, the *ADCIRC* grid we are using as our source of bathymetry has no negative depth values. Similarly, many surveys will only include data points in the water (positive depths). Another method of telling *SMS* which cells are ocean is to use feature objects. This approach can use either polygons or arcs. Polygons can be assigned to be ocean. Then cells inside the ocean polygon are made ocean. Arcs can be assigned to be coastlines. Each arc has a direction and it is assumed that water is to the right of the arc. For this lesson, we will use the coastline arcs that were extracted from the *ADCIRC* mesh. To perform this process:

1. Select the *Select Feature Arc*  tool and select the two feature arcs that pass through, or are in the grid frame.

2. Now, select *Feature Objects | Attributes…* to bring up the *CGrid Arc Options* dialog. Choose *Percent Preference Coastline Arc* as the *Arc Type* and click *OK* to close the dialog. This tells *SMS* that the cells under the arcs should be assigned to be land or water based on the percentage of the cell on the water and land sides of the arc.

3. Next, zoom in even closer on the inlet as shown in Figure 6-4.

4. We want to make sure that at least one string of cells are marked as land to represent the jetties extending from the inlet. To accomplish this, we will use a *Land Preference Coastline Arc*. All cells intersected by a land preference arc are marked as land regardless of how narrow the land strip is. We only want to enforce land through the inlet, so we will split the arcs in that region. To split the arcs, select the *Create Feature Point* tool and click on the tip or each jetty to create nodes there. Create two more nodes where the inlet starts to open up into the bay. Figure 6-4 shows roughly the position of the four newly created nodes. Creating a node on a feature arc splits the arc at the location where the node was placed.

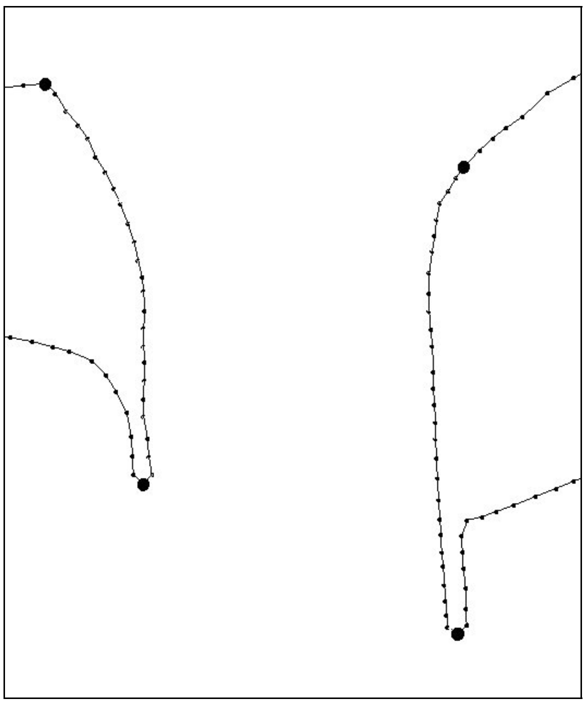


Figure 6-4 Close up of inlet with four new nodes along jetties

5. Now that we have created two new feature arcs along the sides of the inlet, select the *Select Feature Arc*  tool and double click on one of the two new arcs. This will bring up the *CGrid Arc Options* dialog. Select *Land Preference Coastline Arc* as the *Arc Type* and click *OK* to close the dialog. This will ensure that the cells below the jetties will be marked as land cells. Repeat this procedure on the other arc.

6. Before continuing, make sure the newly created arcs are in the correct direction. To do this, select each arc with the *Select Feature Arc*  tool. When the arc is selected two sets of arrows will appear at each end of the arc. One arc in each set will be blue and the other with be brown. The blue arrows should be pointing toward where the ocean cells will be and the

brown arrows where the land cells will be. If the arrows are pointing in the wrong direction, reverse the arc direction by selecting *Feature Objects | Reverse Arc Direction*. All other arcs within the grid frame should also be checked to make sure they are going in the right direction.

We now have everything specified to create an *STWAVE* grid. However, since *STWAVE* is not applicable to compute a wave field inside a harbor or bay where reflection plays a major role, and to make the model run quicker, we can eliminate some of the area within the bay. To do this:

1. On either side of the inlet in the bay, create two new arcs that extend from the existing coastline out of the top of the grid as shown in Figure 6-5. Make these arcs *Percent Preference Coastline Arcs* and remember to make sure they are going in the right direction.

2. Create a node just outside of the grid frame on each of the original coastline arcs. This will create two new arcs that run from the extensions created in step 1 to just outside of the frame. Delete these arcs as shown in Figure 6-5.

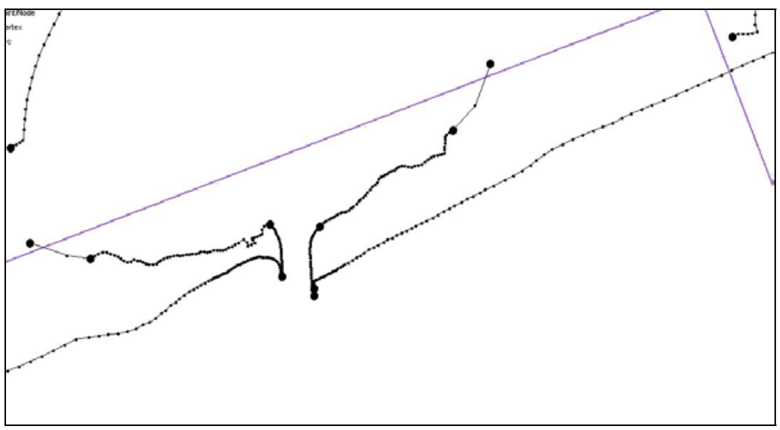


Figure 6-5 Extra arcs extending from inlet to bay and deleted arcs

6.5 Creating the Cartesian Grid

We are now ready to fill the interior of the grid. While the grid is filling, the depth values will be interpolated from the scatter set and mapped to each cell. To do this:

1. Go to *Feature Objects | Map->2D Grid*.

2. In the *Map -> 2D Grid* dialog, set the *Cell Options* to *Cell Size* and set the value to 50 (this will result in cells that are 50 m x 50 m).

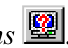
3. Make sure that the *elevation* function will be used to interpolate depth values for each cell in the *Depth* section.

4. Make sure the *Current* toggle is on and *interpolated* is selected. Click on the button with *velocity(64)* on it, and make sure *Single Time Step* is selected. This tells SMS to create a current file for the grid with the current values being interpolated for the selected time. You will just use the first time in the sequence.

5. Push *OK* for both dialogs to create the Cartesian grid. This will take a few seconds (up to 30 on slower machines).

A Cartesian grid has been created from the grid frame. To view the grid only:

1. Go to *Feature Objects* | *Coverages* and click off the *Visible* toggle for the current coverage.

2. Select *Display* | *Display Options* .

3. Switch to the *Scatter* tab.

4. Uncheck the box to the left of the scatter set in the *Visible* box.

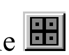
5. Switch to the *Cartesian Grid* tab.

6. Turn on the *Ocean Boundary* and the *Contours.* Turn off the *Ocean Cell* and *Land Cell* and push *OK*.

6.6 Editing the Grid and Running STWAVE

6.6.1 Model Control

In the Model Control, *STWAVE* inputs can be set. To set our parameters:

1. In the *Cartesian Grid* module  select *STWAVE* | *Model Control*.

2. Change the *Source Terms* to *Source Terms and Propagation*. Note that the grid parameters are shown at the top of this dialog. Be careful to not change any of the *Define Grid* parameters. If those are changed, the grid will be regenerated with the new settings and all depth and current information will be lost.

3. Change *Wave Direction* to *Local*.

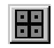
4. For this run, leave *Wave Current Interaction* as *None*.

5. Change *Radiation Stresses* to *Calculate*.

6. Push *OK* to exit the dialog.

6.6.2 Generating Spectral Energy Distribution

We will now generate the Spectral Energy distribution.

1. In the *Cartesian Grid* module  choose *STWAVE | Spectral Energy*.

2. Change the *Index* to "1" and push the *Generate Spectra* button. In the frequency column (*f Hz*), enter "30" for *Number*, "0.04" for the *Min*, and "0.01" for the *Delta*.

3. Change the Index of the first line to 1. Make sure the height (H) is set at 1 meter, the period (T) is 6 seconds, the angle is 30 degrees, the frequency spread factor (gamma) is 3.3 and, the directionsal spread factor (nn) is 4.

4. Push the *Generate* button. The contours show the energy distribution. Select nodes (cell corners) to view/edit their energies.

5. Push *OK* to exit the *Spectral Energy* dialog.

6.6.3 Selecting Monitoring Stations

The final step is to select cells to act as monitoring stations:

1. Select the *Select Cell*  tool.

2. Select a cell in the inlet. The i,j location can be seen in the bottom left in the *Help Window* when a cell is selected. (Click on the screen to select a cell.)

3. While the cell is still selected, choose *STWAVE | Assign Cell Atts*. Turn the *Monitoring Station* toggle on and push *OK*.

4. Repeat steps 2 and 3 and select a cell in the ocean and one in the bay to be *Monitoring* cells. You can also choose an exact i, j or x, y location by going to *Data | Find Cell*. (Note: you could select all three cells at the same time and then assign all three to be monitoring stations at once. Use the Shift while selecting additional cells.)

6.6.4 Saving the Simulation

To save the simulation:

1. Select File | Save As, make sure the Save as type is set to Project Files, and enter the file name "sb_plain.spr."

2. Push the *Save* button.

6.6.5 Running STWAVE

To run *STWAVE*:

1. Select *STWAVE* | *Run STWAVE*.
2. If a message such as "stwave.exe – not found" is given, click the *File Browser* button to manually find the *STWAVE* executable.
3. Click the *OK* button to launch *STWAVE*.

A window will appear and stay up while *STWAVE* runs. Messages will appear to telling what column of the grid is being processed. When *STWAVE* is finished, press the *Enter* key to close the window. This may take up to ten or fifteen minutes.

6.7 Post Processing

The solution files can be opened in SMS and several visualization options may be set.

6.7.1 Visualizing the STWAVE Solution

To see the solution results:

1. Open the solution files by selecting *File* | *Open*, select "shin.sim," and push *OK* at the prompt.
2. Select *Display* | *Display Options* . In the *Cartesian Grid* tab turn the *Contours* and *Vectors* toggles on.
3. Go to the *Contours* tab and set *Color Fill* as the *Contour Method*. Click the *Options…* button and select *Hue ramp* as the *Palette Method*. Push *OK*.
4. Push *OK* to exit the *Display Options* dialog.

6.7.2 Visualizing Bathymetry

The solution files are stored as an SMS solution set when they are opened. The depth is not part of the solution output from *STWAVE*, it is part of the "Generic Datasets" solution. To view the bathymetry:

- Change the Solution (in the *Edit Window* near the top of *SMS*) from "shin (STWAVE)" to "Generic Datasets". Notice that the current *Scalar* function (again at the top) is changed to "Depth."

The contours show the water depth in the ocean.

6.7.3 Visualizing the Direction Field

The *STWAVE* solution files are stored in the new solution. To see the wave direction vectors:

1. Switch the *Solution* back to “shin (STWAVE)” in the *Edit Window*.

2. Change the *Vector* function to “wave.”

The vector arrows show the wave direction field.

6.7.4 Visualizing the Wave Height

To see the wave height:

1. Change the *Scalar* function to “Height.”

The contours show the wave height. Repeat step 1 for “Period” and “Direction.”

6.7.5 Visualizing the Observation (Monitoring Cells) Spectra

To view the observation spectra:

1. Open the observation spectra by selecting *File* | *Open*, select “sb_plain.obs,” and push *OK* at the prompt.

2. Go to *STWAVE* | *Spectral Energy*. Three new spectra have been loaded into SMS corresponding to the three monitoring stations.

3. The spectra for each of the monitoring stations can be viewed by selecting them in the spreadsheet. Only one spectra can be shown at a time, therefore, the contours show the observation spectra for the selected spectra.

4. Push *OK* to exit the *Spectral Energy* dialog.

6.8 Additional Options

Another optional output that you have generated that you have not examined is the wave radiation stress gradients. These are in a file named “radstress”. In future versions this file will be named to match the simulation. You can open this file and visualize the radiation stresses using contours and vectors.

If time permits, you may want to make some additional runs of *STWAVE*. You may want to generate spectra with a different direction and see how this affects the wave results.

Another option for an additional run is to include the effect of currents on the waves. This uses the current data set you created when you performed the Map->2D grid command. In order to turn on the currents go to the model control dialog. Then save the project as sb_current.spr, and rerun. Read in both solutions and compare the effects of currents on the wave field.

6.9 Conclusion

This concludes the tutorial. If you wish to exit *SMS* at this point:

- Choose *File* | *Exit*.